COSMOLOGICALLY SCREWY LIGHT

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We present evidence for a new phenomenon in the propagation of electromagnetic radiation across the Universe, a corkscrew rotation of the plane of polarization not accounted for by conventional physics.

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Electromagnetic radiation propagating on cosmological distances provides an exceedingly sensitive laboratory for new phenomena. Here we summarize observation of an unexpected systematic rotation of the plane of polarization of radio signals from galaxies with redshift $z > 0.3$. We find that the data are explainable in two ways: either invoking unnatural conspiracies among the sources, or proposing new physics.

Radio polarization is produced by synchrotron radiation. However, the observed plane of polarization from distant sources does not usually align with the symmetry axis of the source (denoted ψ). For decades this has been studied in terms of Faraday rotation in the intervening medium. We study a residual quantity remaining after the Faraday effect is taken out.

Extracting Faraday rotation does not depend on models, because the Faraday angle of rotation for wavelength λ goes like $\alpha\lambda^2$. Consistent linear dependence on λ^2 is indeed observed. The problem is that the data fit requires more: for each source (i), the fits are given by $\theta_i(\lambda) = \alpha_i\lambda^2 + \chi_i$. The residual polarization angle χ_i does not generally align with the galaxy major axis; statistics on the differences $\chi_i - \psi_i \pm \pi$ have puzzled astronomers for 30 years [1].

Analysis of the data is challenging, due to several complications. The data set is highly non-uniform in its angular distribution on the sky and in the distances $r(z)$ to the sources. We employed Monte Carlo methods to search for correlations [2]. We make thousands of fake data sets with random polarization and major axis orientations, while keeping the positions of the galaxies the

same as the real data. We then calculate the probabilities of linear correlations observed in the data relative to the random sets.

We find[2] an amount of residual rotation beta described by a dipole rule $\beta = \frac{1}{2}(r/\Lambda_s)\cos(\gamma)$, where γ is the angle between the propagating wavevector and an axis $\vec{s}$ fit to the data. The dependence on the propagation direction is quite novel, indicating anisotropy. Making a cut on $z > 0.3$, which selects the most-distant half of the data set, we find a striking correlation with probabilities that the observed correlation would be produced by random angular fluctuations less than 10^{-3}; the effect is 3.7σ.

A separate study eliminates bias from fitting the s-direction to the data, by fitting the best $\vec{s}$-direction data-set-by-data-set in the Monte Carlo, and calculating the probability of finding the data's correlation relative to the optimized sets so constructed. This gives a probability less than 0.006, corresponding to 2.7σ.

The fits to the parameters are $\Lambda_s = 1.1 \times 10^{25}$ (h_0/h) m, where $\frac{h_0}{h}$ is the ratio of 100 $km(s^{-1})$ $(Mpc)^{-1}$ to the Hubble constant, while $\vec{s} = (0^\circ \pm 20^\circ$ declination, 21 ± 2 hrs right ascension). The scale Λ_s is 1/10 the Universe's size; the effect is far too small to affect laboratory measurements. We do not find a significant correlation for $z < 0.3$; in our full data set we also do not find a significant correlation of $\beta = (const)\ \ r$.

We are not the first to find puzzling statistics in the residual angle [1]; the problem is that our correlation cannot be reconciled with conventional ideas. Explaining the effect via population dependence among the sources requires an unnatural conspiracy across the sky. The role of systematic errors, with the possibility that the angular correlation might arise in a local effect, is crucial. The observers deny this possibility; more importantly, the proposal is ruled out by the fact that the near half of the data does not have the correlation. New physics explanations are available [2]; perhaps the most conventional proposal would be domain walls of an axion–like condensate. The prediction of exactly the dipole rule in a different model [2], and the search for a limit, led to the present investigation.

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References

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